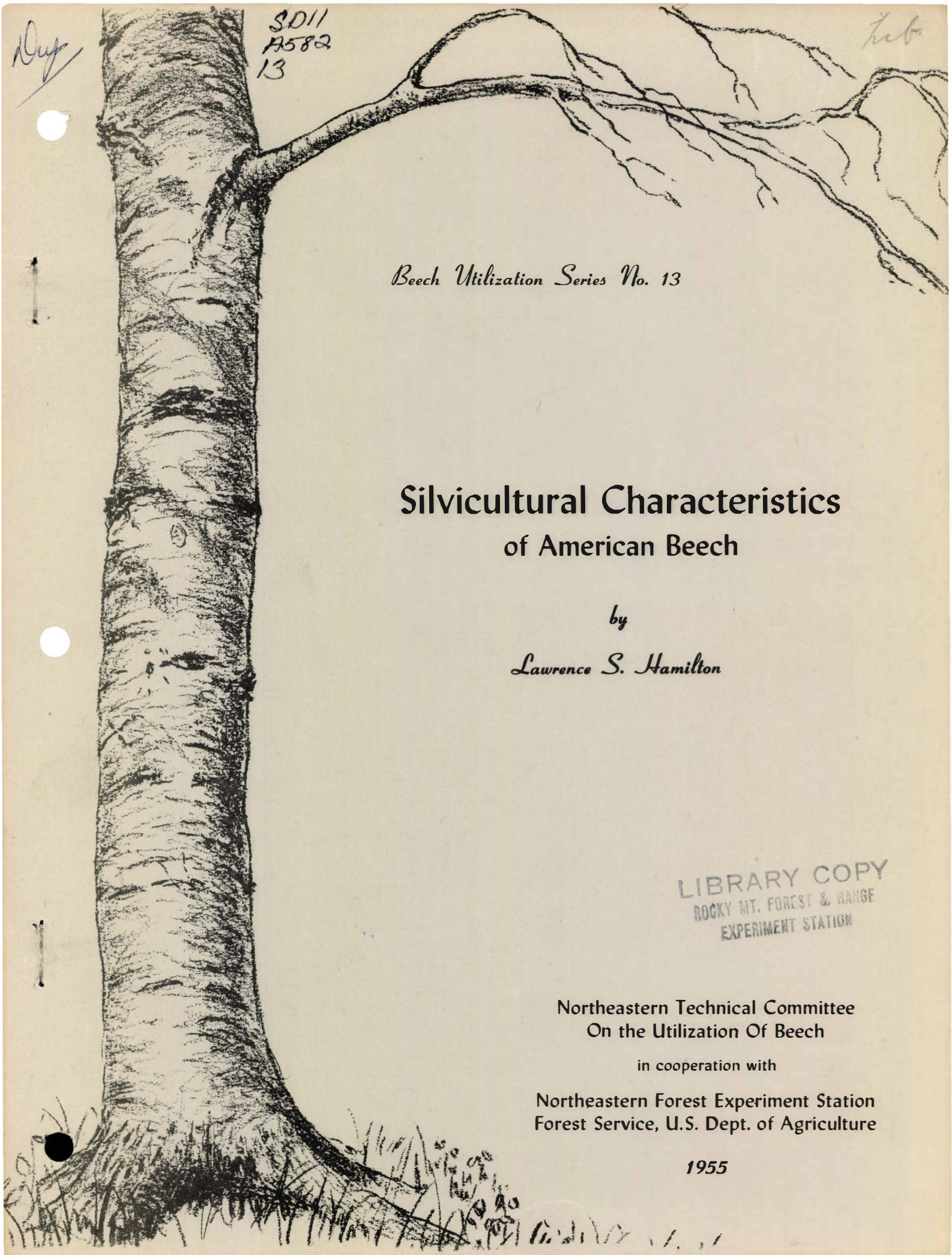

Beech Utilization Series No. 13

Silvicultural Characteristics
of American Beech

by

Lawrence S. Hamilton

Northeastern Technical Committee
On the Utilization Of Beech

in cooperation with

Northeastern Forest Experiment Station
Forest Service, U.S. Dept. of Agriculture

1955

FOREWORD

The wood of the American beech tree (Fagus grandifolia Ehrh.) is well suited for a large number of uses, and it is rather widely used by manufacturers. Yet the amount used is not in proportion to the amount that grows in our northeastern forests. The utilization of beech--both in the woods and in the factory--has been recognized as a problem.

One reason for this is in the nature of the wood: it has a reputation for being difficult to season. Another is that many of the beech trees in our forests are of poor quality. And there are some plain prejudices against beech.

Research is finding ways to utilize beech as efficiently as any of the other comparable hardwoods can be handled. Considerable information about beech has been gathered. Yet most of this information is available only in fragmentary form in scattered technical reports. Some of it has never been published.

To study the problems of putting beech to the uses it deserves, and to promote the better management of the forests in which it grows, a Northeastern Technical Committee on the Utilization of Beech was organized in 1949. This committee, which includes representatives of Federal and State forestry agencies, universities, and state experiment stations, decided to assemble and publish the available information about the utilization of American beech.

As its part of this cooperative project, the Northeastern Forest Experiment Station has undertaken to edit, publish, and distribute the series of reports that will contain this information.

The subjects of these reports will be as follows:

* Physical and mechanical properties of American beech.

(CONTINUED ON INSIDE OF BACK COVER)

ACKNOWLEDGMENTS

Grateful acknowledgment is made to three men: John R. Curry formerly of the Northeastern Forest Experiment Station, Paul Smiths, N. Y.; Professor Svend O. Heiberg Head of the Department of Silviculture, College of Forestry, State University of New York at Syracuse, N. Y.; and Dr. Earl L. Stone, Assistant Professor of Forest Soils, Department of Agronomy, Cornell University, Ithaca, N. Y. The contributions of these men through discussion and critical review of initial drafts of this paper merit deep thanks.

A great deal of help was also rendered by the members of the Northeastern Technical Committee on the Utilization of Beech. To each of them the author is indebted for their criticisms and suggestions.

CONTENTS

Silvicultural Characteristics
of American Beech

by

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MANAGEMENT OF A TREE species is based on an understanding of its silvicultural characteristics. There is a startling lack of available literature on the requirements, characteristics, and behavior of American beech (Fagus grandifolia Ehrh.). This reflects the past lack of a positive management attitude toward the species. Consequently, in discussing beech the author has been forced to draw somewhat on the published material about European beech (Fagus sylvatica L.).

OCCURRENCE OF BEECH

Fagus grandifolia, one of several species of Fagus in the Western Hemisphere, is the only one native to North America. In various localities it has been called white beech, gray beech, red beech, stone beech, and ridge beech.

The distinctly red heartwood of some beech has been responsible for the popular belief that red beech is a different species. Most authorities recognize no botanical

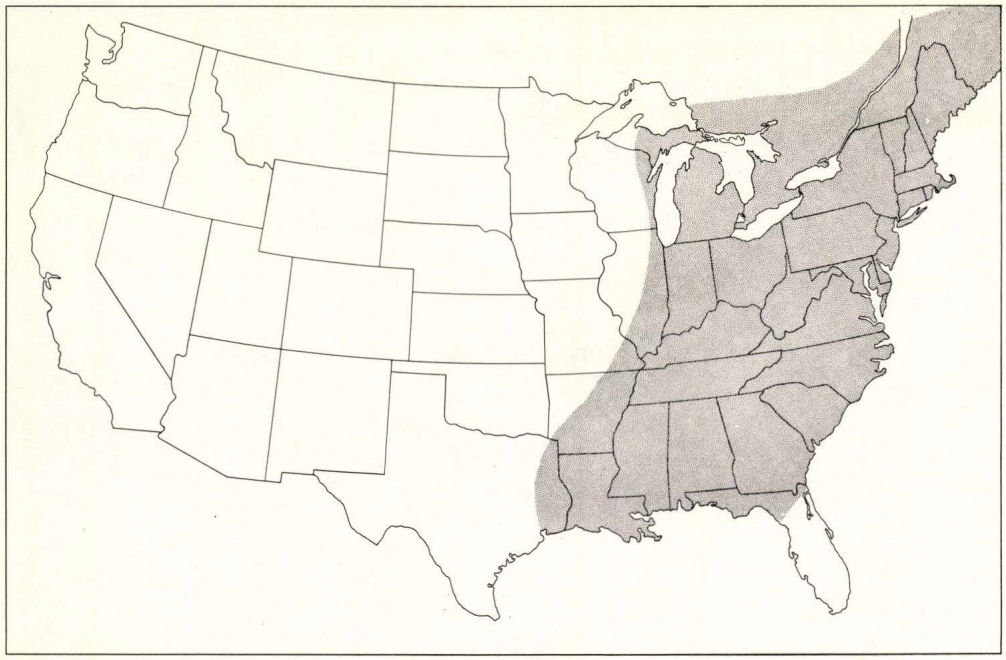

Figure 1.--The natural range of beech.

difference; they say that these various local names all apply to the same species. However, Braun (4)[1] describing recent unpublished work by W. H. Camp, states that there are at least three distinct genotypical races, which may even be distinct species.

The range of beech is from Nova Scotia to northern Florida, and from the Atlantic Coast westward to Ontario, Wisconsin, Missouri, and Texas (fig. 1). It occurs on the uplands and mountain slopes in the northern part of its range, and on the bottomlands in the south. Its maximum development is reached in the lower valley of the Ohio River and on the slopes of the southern Alleghenies (23).

Beech usually grows in mixture with other species, or in small pure groups within a mixed forest. Pure stands of beech occasionally are found on rocky stream flats in the southern Appalachians at elevations of 2,500 to 3,000 feet

[1]Underlined numbers in parentheses refer to Literature Cited, page 35.

(36). Stands that are almost pure beech have been created by cutting in certain parts of the central Adirondacks, in northern and eastern Ohio, and in central Indiana. Cain (7) and Esten (16) report virgin stands in Michigan and Indiana that are very nearly pure beech, if only trees above 6 inches in diameter are considered. However, both writers found the ratio of maple to beech in the lower strata to be such that maple will tend to increase in importance as natural succession develops.

Three forest regions, namely the mixed mesophytic forest, the beech-maple forest, and the hemlock-white pine-northern hardwoods forest, have beech as one of the dominant species (4). In existing forest-cover types, as classified by the Society of American Foresters (36) beech is an important species in the following types:

Number 12. Sugar maple-beech-yellow birch.
Number 17. Red spruce-sugar maple-beech.
Number 57. Beech-sugar maple.
Number 58. Beech.
Number 79. Beech-evergreen magnolia.

Beech occurs in varying abundance as an associate in 11 other types.

Accurate figures for the existing volume of standing beech do not exist. The United States Forest Service reappraisal survey of 1945 gives the volume of beech, yellow birch, and sugar maple together as 67,887 million board feet to a minimum diameter of 11 inches (42). The volume of these three species in the Northeast is given as 40,050 million board feet. It is estimated that beech alone constitutes almost 20 percent of this total.

SILVICULTURAL CHARACTERISTICS

Site Requirements

Beech is adaptable to a great range of climatic conditions, and it will exist on a considerable range of soil conditions. Its very adaptability has helped to create the situation commonly called "the beech problem."

Certainly on deep, well-drained, fertile soils, with adequate moisture and suitable climatic conditions, beech can be a worthwhile component of the stand. On such sites,

Figure 2.--On favorable sites beech can be a worthwhile component of forest stands.

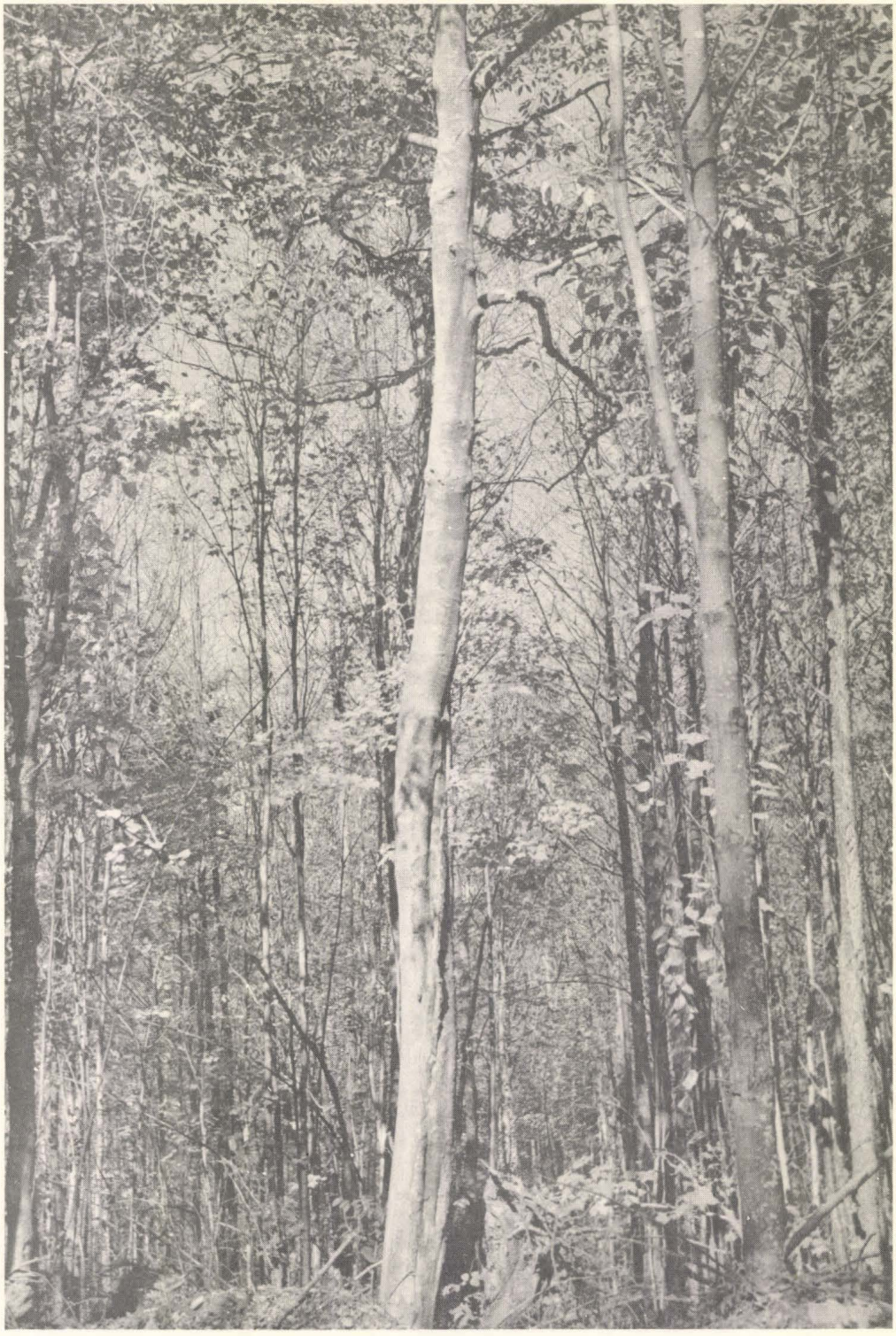

Figure 3.--On poor sites beech manages to hold on rather tenaciously, but is of very inferior quality.

under good forest management, vigorous trees with clear, straight, massive trunks, free of frost cracks, may develop (fig. 2).

But the ability of beech to exist on sites that are unfavorable in one or more respects often makes it an undesirable component. On these sites, its vigor, form, and ability to recover from injury are poor (fig. 3). The undesirable condition of the beech on favorable sites is often due to poor management. On unfavorable sites poor management of beech aggravates an already bad condition.

Climate

Beech occurs in a relatively humid region. The fact that there is sufficient or excess moisture causes the forest to occupy the soil very densely, so that only the very tolerant trees can compete for a permanent place in an undisturbed forest. Beech is such a tolerant species.

The variation in climatic factors under which beech will exist is so great that generalization is useless. Any species found from 31 to 47 degrees North latitude, and from tidewater to mountain slopes as high as 5,500 feet, can hardly be called exacting in its climatic requirements. Some idea of the climatic variation throughout the range of beech is given by Livingston and Shreve (27):

Normal frostless season: 95 to 281 days.
Normal daily mean precipitation: 0.091 to 0.172 inch.
Normal mean relative humidity for year: 67.5 to 85.2 percent.
Normal total duration of sunshine: 1225 to 2650 hours.

For optimum development, the climatic range is much smaller. Favorable climatic conditions prevail in the lower Ohio Valley and in parts of central New York and northeastern Pennsylvania.

The westward extension of beech is limited, in general, by high temperature and low precipitation in June (13). In the Upper Peninsula of Michigan, however, the westward extension is apparently limited by a difference in soil characteristics.

The northward and altitudinal limit of beech is determined chiefly by extremes of low temperature. The altitudinal limits of the main forest type in which beech occurs in the Northeast are given by the Committee on Forest Types

of the Society of American Foresters (36) as follows: "In northern New England and New York (this type) goes up to 3,500 feet, in the Lake States to 1,600 feet and in the southern Appalachians occurs in a zone from 3,500 to 5,000 feet in elevation."

A striking example of the killing of beech by low temperatures occurred in the Northeast in 1934. This was reported by Spaulding and Hansbrough (38) and several others, who attributed it to a combination of the extremely dry summer of 1933 and the very low temperatures (-40° to -50° F. in some areas) for a short period the following winter. Cain[2] set forth evidence that indicated low temperature alone was responsible. Winter killing has been observed in other years (31), and in most cases beech was the most susceptible of the deciduous species to such injury.

In the northern and upper altitudinal limits of beech's range, large frost-crack seams are common. The worst example of large areas of frost-split beech the writer has seen is in the northern Adirondacks on the Northeastern Station's experimental forest at Paul Smiths.

Late spring frosts often damage the new shoots of many species. Little is known about this aspect of climatic injury to beech. American beech is generally regarded as being no more susceptible to such injury than many other species. But Schlich (34), referring to European beech, says that late spring frosts are one of the greatest enemies of young beech.

Soils

Beech will grow over a wide range of soil conditions. Undoubtedly it performs best on neutral or slightly alkaline soils of high fertility and adequate moisture. Since it occurs on soils that do not have these characteristics, the more extreme the departure from the ideal conditions, the poorer does the beech become in its commercial characteristics.

The soil profile types, under stands in which beech is an important component, range from brown forest through

[2]Cain, R. L. Winter killing of beech on Huntington Forest. 91 pp., illus. 1942. (Unpublished thesis, N.Y. State Univ. Coll. Forestry, Syracuse.)

to podzol. The humus layer may be anything from a coarse mull to a granular mor. This is indicated by the plant associates of beech such as jack-in-the-pulpit and sweet jarvil, which are characteristic mull plants; and wild lily of the valley and wood sorrel, which are mor plants.

Beech occurs on every type of soil from sand to clay loam, and occasionally even on peat. In the Adirondacks it is abundant on the prevailing stony sandy loams of acid igneous till. Here too, it occurs on sands and gravels of outwash areas; but because of lack of fertility and lack of sustained moisture, rarely does it develop into a good tree.

The presence of available moisture throughout the summer is necessary for the good development of beech. As a result of studying the maple-beech association in northern Michigan, Gleason (19) concluded that soil moisture is the controlling soil factor in determining the presence and proportion of beech. Seedlings are especially susceptible to drought. Gleason and many others have written of the mortality of beech seedlings on high, well-drained sites in years of severe drought. Where there is a thick matted mor, seedlings may succumb to desiccation even though there is adequate soil moisture. This is probably due to the extreme fluctuation of the moisture content of the humus, and to the fact that the young seedling roots may ramify in the raw humus alone without getting down to mineral soil (37).

The range of soil acidity is from very acid to calcareous. Although some writers report no correlation between the presence of limestone and the occurrence of vigorous beech (9), most observers agree with Heimburger (25), who found that beech is often associated with outcrops of limestone.

That beech may be restricted in occurrence by the lack of adequate available calcium is well illustrated in the Upper Peninsula of Michigan. In that region, a rather well-defined line marks the westward extension of beech. The virtual absence of any beech west of this line is apparently due to a deficiency in available calcium.

Many unscientific statements about the ability of beech to "forage" or seek lime appear in the literature. Most of these trace back to European writings in which beech was described as a "lime pump," which would improve soils of low calcium level by bringing calcium up from the soil depths and making it available in the surface layers. This

belief was responsible for a great deal of the underplanting with beech in European forests. This view has generally been discredited for American beech, largely through studies such as that of Chandler (8), which showed that the leaf litter of beech was the lowest in calcium of any of 15 common deciduous trees. The present use of beech for underplanting in Europe is due to the desire for introducing deciduous trees into pure conifer stands, and the fact that the tolerance of beech permits such underplanting.

The soil depth required by beech is extremely variable. Beech thrives on a deep soil, but if moisture conditions are favorable, it can grow where the soil mantle is as shallow as 6 inches. The adaption of the root system to soil depth is marked with this species.

The variation in the form and general condition of beech is closely related to the level of soil productivity. Highly podsolized infertile sands produce only the poorest types of beech, which are merchantable only when bulk wood markets exist. Soils of high fertility are capable of producing good beech that will yield high-quality lumber, veneer, or other special products.

Species Features

Light Requirements

In general, beech is regarded as very tolerant of shading. Of all its associates, only sugar maple, hemlock, red spruce, and balsam fir may be grouped with beech in the classification "very shade tolerant."

Cheyney (9) has stated that beech seedlings require some shading for successful establishment and development. Gordon (20), who worked with European beech, took the same view. However, in a comprehensive study of the light requirements of European beech seedlings, Watt (45) concluded that the optimum light intensity for survival was full sunlight. The failure of American beech seedlings to establish in the open is probably due to factors other than a requirement for shade. Watt also found that the minimum light intensity for survival was around 1/60 full sunlight, which seems to correspond to the requirements of our American beech.

Sapling beech can withstand fairly dense shading for many years, and then can recover from suppression and grow normally when light is admitted. In such cases, however, the trees often become flat-topped and develop crooked stems. We may be attributing to young beech a great deal more shade tolerance than it actually possesses, for many of the young densely shaded saplings in our stands are root suckers, which can depend on the parent tree for photosynthate.

Morphological Features

The variation in morphological features of beech is great. While most species vary considerably according to site, this is especially marked with beech. On one site, in even-aged groups, the individuals are often heterogeneous with respect to form, diameter, dominance, and other external characteristics.

On sites where it reaches its best development and where it is properly managed, beech is a relatively smooth-barked columnar tree that may attain a diameter of 3 feet or more and a height of 120 feet. Although the growing situation and inheritance change bark characteristics, beech generally has gray, thin, smooth, and close-fitting bark. These features make it one of the best known trees in the Northeast. Under forest conditions in closed stands it prunes well (fig. 2). If beech receives much side light, however, the trunk is generally short, breaking up into many heavy spreading limbs that form a broad round-topped crown (fig. 4).

Beech is a long-lived tree on good sites, for ages of 250 years are often recorded when old stands are cut. Harlow and Harrar (23) say that beech may attain ages of 300 to 400 years.

The form of beech varies considerably with the quality of the site. The average form class for beech in the Northeast has been given as 84 by Mesavage and Girard (28). The thin bark of beech contributes to its attaining such a high rating. Such high form classes occur only on the better sites and it is rather doubtful that the average should be so high. On poor sites, where beech is often found, the taper is greater; and much lower form classes prevail.

The root system of beech is generally wide and moderately deep, but as with most trees this varies with soil conditions. Part of the success of beech may be attributed

Figure 4.--A beech tree that receives much light from the side is apt to develop a short trunk that breaks up into many heavy, spreading limbs.

to its accommodating root system. Harley (22) points out that root growth is influenced by light, and that shaded European beech tend to have poorer root systems and lower root/shoot ratios.

Little has been recorded about the root habit of American beech. In general it appears to be neither a tap-root system nor a flat root system, but something in between. In this respect it is similar to European beech, which is described as having a "heart root" (6). According to Vater (44) and Büsgen and Münch (6), European beech seedlings develop a very marked tap root that constitutes the main root system for the early years. The length of time this root remains functionally important varies with soil conditions. In the beech he studied, Vater found that the tap root was retained up to 27 years. As the tree ages, a mass of side roots develop near the root knot and penetrate obliquely into the soil. In this way the tap root changes to a heart root.

Moore (30) likens the root system of American beech to that of red and white spruce in the development of a dense network of branches that occupy the humus completely, but points out that it has deep feeding roots in the mineral soil. He says there must be intense root competition between beech and the spruce where they occur in the same stand. On shallow soils the network of surface feeding laterals may completely replace the deeper root systems formed on deep soils (46).

Root grafting is common with beech. The ability to sprout from the roots is marked and this characteristic contributes greatly to the beech problem. Root sprouting will be discussed under reproduction.

Reproduction

The following information on seed and seeding habits is extracted from the Woody-Plant Seed Manual of the U. S. Forest Service (41).

> The male and female flowers of beech are borne separately on the same tree and bloom in the spring after the leaves unfold...the female flowers develop into two or three one-seeded nuts surrounded by a prickly bur, which opens on the tree soon after maturity in the autumn, allowing the nuts to fall to the ground. F. grandifolia bears good seed crops every 2

Figure 5.--A dense growth of root suckers. The parent stump itself has sprouted very little.

> to 3 years, with light seed crops in most intervening years...(it) begins to bear seed in commercial quantities at 40 to 60 years.

Pinchot and Ashe (33) and others report that good seed crops are produced every 4 to 5 years. It is possible that the periodicity is different in the northern and southern parts of beech's range.

Those nuts not damaged by insects and fungi, or consumed by animals, germinate from early spring to early summer where seedbed conditions are favorable. Because of the weight of the seed, dispersal is restricted to the area immediately surrounding each parent tree, unless seeds happen to be dispersed by animals or water or other means. In the Northeast, all of the common and important associates of beech except the oaks and hickories have lighter seed, capable of wider dispersion.

Beech stumps produce masses of adventitious shoots after cutting. However, stump sprouting is seldom an effective means of regeneration when the stumps are over 4 inches in diameter. The root suckering of beech is of much more serious consequence (fig. 5).

The origin of these root suckers is not fully understood. European beech does not sprout from the roots, and therefore this problem has not concerned European investigators. It is commonly believed that suckers arise on the surface roots wherever there has been wounding. Beech in undisturbed parts of the Adirondacks sucker abundantly without grazing, fire, or logging injury; but the origin could still be injury to tissue by frost, insects, small mammals, or heaving due to wind action. The author has observed root suckers arising from callus formations on the underside of surface roots; but again this could be attributed to injury by some external agency. These root suckers are often deformed and infected with rot from the old root system, and are not desirable reproduction. They often come up so densely around the parent tree that they prevent the growth of more valuable reproduction. Most observers report that they rarely attain merchantable size. Illick and Frontz (26), however, report one stand of root-sucker origin, that at the time of their writing was 40 years old, and averaged 4 inches in diameter and 38 feet in height.

Susceptibility To Injury

Non-living agents.--Though the root system of beech is not an extremely deep one, it is not easily uprooted by wind. This was shown recently in the Northeast in the severe windstorm of November 1950, when relatively few beech were uprooted. Beech is not especially susceptible to injury in glaze storms, as are black cherry (14) and silver maple, though Gustafson[3] reports that beech is slow to recover from any such injury.

In the northern and upper altitudinal limits of its range, frost damage may be severe on beech (fig. 6). The frost cracks are often not superficial cracks such as appear on many other species, but are deep seams that go right in

[3]Gustafson, R.O. Glaze damage with special reference to the northern hardwood region. 139 pp., illus. 1938. (Unpublished thesis, Univ. Mich. School Forestry and Conserv.)

Figure 6.--Frost crack on beech. This kind of injury is common in the northern and upper altitudinal limits of the range of beech.

to the pith. In other parts of beech's range, frost cracks may be only on the surface, and although they appear like a ruinous defect, most of the injury is removed in sawing.

The thin bark of the stem and the surface roots renders beech particularly vulnerable to fire. Sunscald has inflicted damage on thin-barked reserve trees where stands have been opened too rapidly and heavily; but this is not an important injury.

Wildlife.--The seed of beech is highly palatable not only to man but to many other animals. The activities of wildlife may considerably affect the success of beech in competing for a place in the forest. When available, beech nuts constitute an important part of the diet of white-footed mice, squirrels, chipmunks, black bears, foxes, ruffed grouse, wood ducks, and bluejays. Watt (45), reporting on the enemies of beech reproduction in Britain, says that in years of low mast production, mice and birds may prevent or seriously interfere with natural regeneration. If it were not for root suckering, the same might be true of American beech.

Though deer, rabbits, and hares may browse beech shoots within reach, they prefer other tree species such as basswood, the ashes, and the maples. Where browsing is heavy, beech thereby gets an advantage over many of its associates. The influence of deer browsing on understory composition is very apparent in many areas that have large winter deer populations.

The bark of seedlings and saplings is eaten by mice, hares, and rabbits. Though severe damage has been reported in the Northeast, Watt (45) tells of damage to European beech up to 1 foot in diameter by rabbits, and mice nibbling through sapling stems 1 inch in diameter.

Grazing.--Cattle and sheep browse seedlings and young shoots on sapling beech, but they too prefer ash, basswood, and elms over beech. Considerable injury is inflicted on beech's thin-barked surface roots by the hooves of grazing animals. This type of injury can be seen in almost any pastured woodlot. Decay and root suckering frequently follow such damage.

Logging.--Damage to branches, trunks, and roots occurs during the process of logging. Hall (21) studied 65 plots in cutover stands in New England and the northern Lake

States, and found that of 1,021 residual trees, 253 (25 percent) showed logging scars of some nature. If a thin-barked species such as beech were considered alone, the percentage of injured trees would certainly be greater than this.

Post-logging decadence is not solely the result of wounding. Hall points out that "logging, however, undoubtedly contributes most to decadence by the changes which it effects in the physical factors of the environment." He points out that extreme temperature and moisture changes following opening-up of the stand may cause death. This would apply especially to beech, whose feeding roots are close to the surface.

Belyea (2) studied post-logging mortality in the vicinity of Cranberry Lake, New York, and found that the mortality among beech residuals was high. On two plots of mixed northern hardwoods and one plot of spruce-hardwoods, he found the percentage loss of residuals to be highest for beech on two of the plots, but exceeded by yellow birch on one plot. At present, yellow birch is generally considered to be the greatest risk after logging in the beech-birch-maple type, but beech would rank a close second.

Insects.--The most serious insect enemy of beech is the beech scale (Cryptococcus fagi Baer.). This pest of European origin was first discovered in the United States near Boston in 1929. It is now present almost wherever beech occurs in the following areas: in Maine; on the eastern slope of the White Mountains in New Hampshire; in Essex, Middlesex, and Suffolk Counties in Massachusetts; in the Hartford, Connecticut area; in the Rutland, Vermont area; in Nassau, Westchester, and Sullivan Counties of New York; and in northeastern Pennsylvania, and New Jersey (11, 12).

Widespread killing of trees apparently occurs only when attacks of beech scale are followed by infection with the fungus Nectria. Heavy scale attacks will impair the vigor of the tree, and in many instances large areas of bark and cambium may be killed. Ruptures in the bark caused by the feeding of these insects provide the avenues of entry for Nectria infection. The scales attack trunk, branches, and exposed roots of trees of all ages (fig. 7).

Infestations of beech scale are periodically reduced when abnormally cold winter temperatures (below -35° Fahrenheit) occur (11). The twice-stabbed lady beetle (Chilocorus

Figure 7.--A beech tree infested with beech scale. The scale is a small sucking insect that attacks the bark of beech trees. This opens the way for Nectria fungus, which often kills the tree.

stigma) is a predator on the beech scale and at times is effective in reducing the population of this insect (12).

Beech is also attacked by leaf-eating insects such as the gypsy moth, cankerworm, and forest tent caterpillar; but beech is not their preferred food. Tree vigor is impaired when epidemics build up and when repeated defoliation occurs.

Diseases.--The most serious disease of beech is the beech bark disease (fig. 8), which is due to infection by a Nectria fungus (Nectria coccinea var. faginata, Lohman, Watson, and Ayers) following attacks by the beech scale. Severe damage or death results from heavy infection. Ehrlich (15) has made an intensive study of this condition and describes its appearance, progress, and the relationship between the insect and the fungus. He shows a positive correlation between the incidence of the disease and the percentage of beech in the stand, the steepness of the slope,

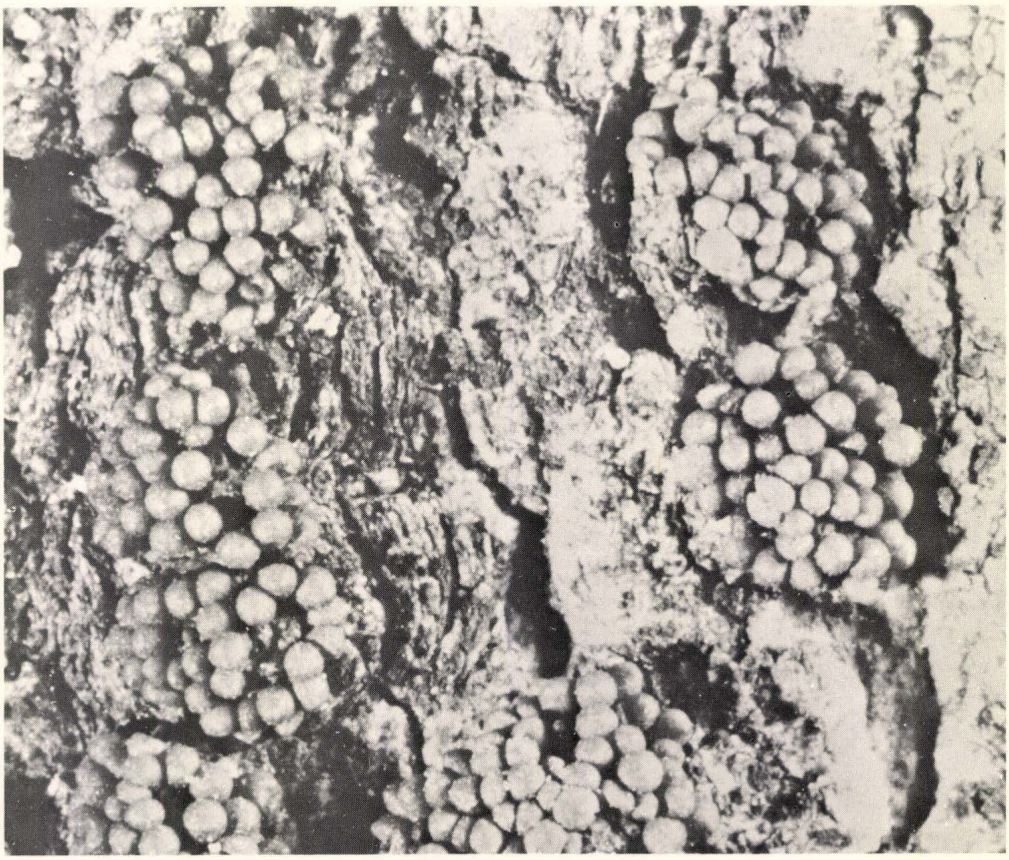

Figure 8.--A close-up of beech bark disease.

the position on slope, and the diameter of the trees. He also shows correlation between percentage of beech mortality and the diameter, crown class, and position on slope or top of ridge.

Beech bark disease has been reported generally throughout eastern Maine, and in isolated localities in the rest of the State; on the eastern slopes of the White Mountains in New Hampshire, and in the Catskill Mountains (Sullivan County) of New York (12). Hansbrough [4] reports that the beech bark disease has now been found on the Green Mountain National Forest in Vermont. The fungus is generally found from 2 to 5 years after the appearance of the insect in a new locality. Boyce (3) reports that in Canada, after the disease had been present in a stand for 4 years, 20 percent of the beech were killed; and after 10 years, 50 percent. The disease has been and is still spreading westward following the distribution of the scale insect, and it is apparent that losses of beech in Northeastern forests will be high.

Beech is also subject to infection by other species of Nectria, notably the canker Nectria galligena Bres. Its occurrence on beech, however, is much less than on yellow birch, paper birch, black birch, red oak, black oak, and basswood (47). Trees infected by these stem cankers are rarely killed outright. The cankers provide means of entry for other diseases or for insects.

Other diseases common to many deciduous trees are important causes of deterioration in beech. The most serious are the wood rots, Fomes igniarius (L.) Gill., F. applanatus (Bers.) Wallr., F. connatus (Weinm.) Gill., and Polyporus glomeratus Peck. Boyce (3) gives excellent descriptions of these wood rots. Beech is especially vulnerable to these fungi because its thin-barked stem and surface roots are so easily wounded by fire, frost, logging, and animals. F. igniarius is particularly destructive to beech in the Northeast (fig. 9). Observations made in the White Mountains and nearby areas indicate 50 to 100 percent cull, if one or more fruiting bodies of this fungus occur on the lower trunk (39).

According to Silverborg, (35) the fungus Polyporus glomeratus is one of the important causes of serious heart

[4] Communication from J.R. Hansbrough, Northeast. Forest Expt. Sta. 1954.

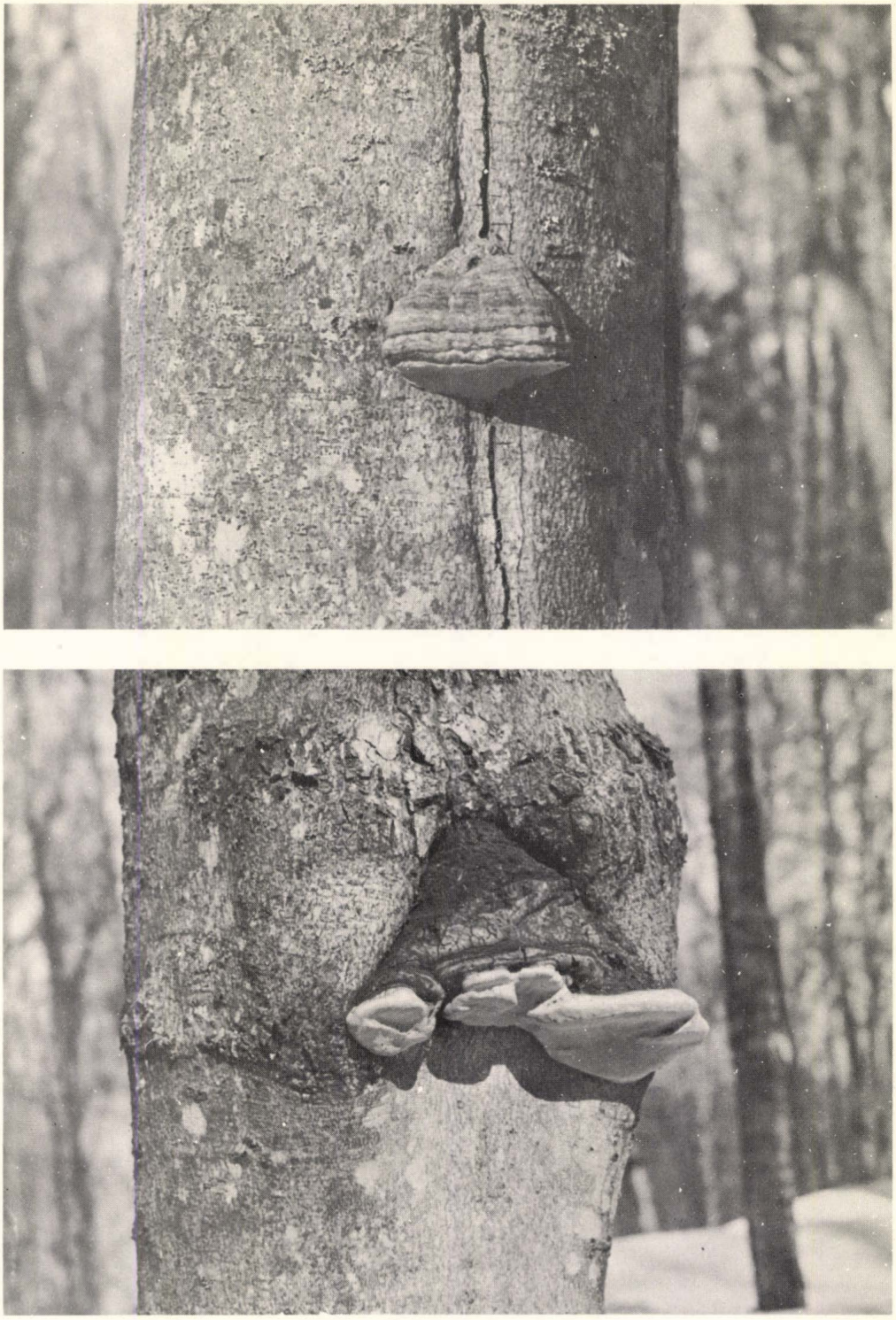

Figure 9.--Fruiting bodies of *Fomes igniarius* on beech trees. The conk shown in the top photo is the more typical in form.

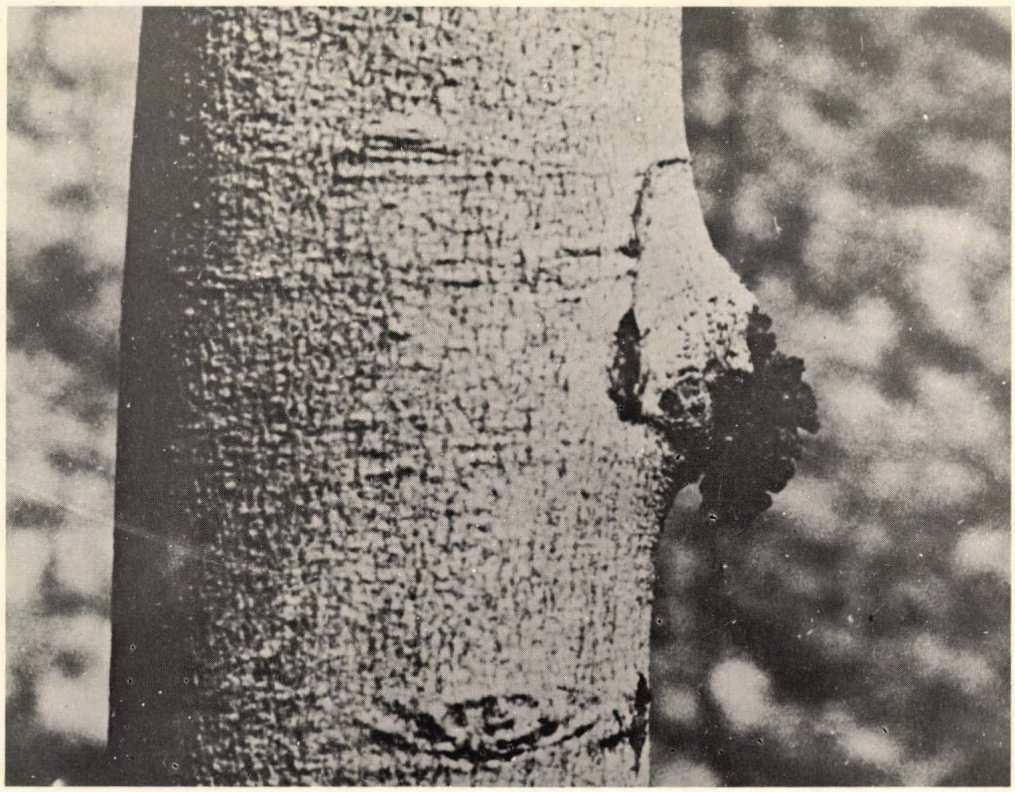

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Figure 10.--Sterile conk of *Polyporus glomeratus* on a beech tree. This indicates serious heart rot.

rot of beech in parts of the Northeast (fig. 10). He reports that a single sterile conk or canker usually indicates 5 to 6 feet of heart rot in both directions on the stem.

Fomes applanatus and F. connatus commonly occur in the butt following injury. Although such butt decay may appear serious, it generally does not extend more than 4 to 6 feet up the bole (39). However, even the butting-off of a 2- to 3-foot section can waste as much as 9 percent of the merchantable cubic-foot volume of the tree, from what is ordinarily the most valuable portion of the stem.

Several other fungi infect living beech. A complete list of these diseases is given in the Index of Plant Diseases in the United States (43). Two fungi that are listed but have until recently been regarded only as minor in importance are Ustulina vulgaris Tul. and Fomes fomentarius (Fr.) Kickx. Silverborg (35) indicates that they must be

considered as important enemies of living beech, and indicates appropriate cull deductions for them.

Miscellaneous injury.--Beech trees seem to be especially vulnerable and attractive to amorous swains and small boys with sharp knives, for the tree lends itself well to bark carving. This is not a new pastime, for Virgil has written:

> "Or shall I rather the sad verse repeat
> Which on the beech's bark I lately writ?"

Defect

The amount of cull in beech in unmanaged stands is high. This is true throughout the whole range of beech. A handbook for foresters in the Central States and southern part of the Lake States gives the proportion of cull for beech as 35 percent in old-growth stands and 20 percent in second-growth stands (40). These percentages are given for use in converting gross volumes to net volumes, and do not include cull trees. The only other species listed with as high cull factors are blackjack oak and willow.

A current survey in the southern zone of the Adirondacks shows 21.9 percent of the cubic-foot volume of the sampled beech to be cull.[5] From studies made in the Anthracite Region of Pennsylvania, Ferree (17) presents cull factors for beech, black birch, red maple, white oak, black cherry, yellow-poplar, white pine, and hemlock. In site 1, sawtimber stands, beech has a higher cull factor, in every diameter class, than any other species except black birch (table 1). Above 14 inches in diameter the cull factors for black birch are equal to or slightly greater than those for beech. On site 2, beech and black birch have the greatest cull factors, with black birch leading above 8 inches in diameter.

Bailey and Heald (1), in preparing local volume tables for Vermont hardwoods, found that beech logs were more defective than either sugar maple or yellow birch. Fifty-one percent of all beech logs examined contained defects, as compared with 45 percent for maple and 43 percent for birch.

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[5] Data from Adirondack-Catskill forest survey, New York State Univ. Coll. Forestry, Syracuse. December 1951.

Table 1.--Cull factors for beech growing in natural sawtimber stands in the Anthracite Region of Pennsylvania

(Percent of total cubic-foot volume, to a 4-inch top)

D.b.h. (inches)	Site 1	Site 2
4	12	12
6	14	14
8	16	16
10	18	19
12	21	22
14	24	26
16	27	30
18	31	34
20	35	39
22	40	44
24	46	50

Source: Feree (17).

These investigators also found that when the logs were opened up, beech contained much more hidden defect. The type of visible defects in 320 beech logs examined is shown in table 2. Well over half the logs contained crook or sweep defects.

Table 2.--Character of defect in 320 beech logs examined in Vermont

Type of defect*	Logs showing defect
	Number
Butt defect	29
Top defect	20
Crook	121
Sweep	69
Knotty	42
Seam	21
Miscellaneous	18

*Logs having more than one defect are classified by the defect that is most serious.
Source: Bailey and Heald (1).

Poor form (largely crook and sweep, but also short merchantable length and coarseness of branches) must take blame for a great deal of the poor regard in which beech is held (fig. 11 and fig. 12). In site 2 sawtimber stands in

Figure 11.--Crook is a common defect in beech.

Figure 12.--Sweep is also a common defect in beech.

the Anthracite Region, 49 percent of the beech volume examined was found to be of poor form (5). The same study indicated that in seedling-and-sapling stands on site 1, the beech was 56 percent poorly formed. Much of the poor form is due to the beech being held in a subdominant position in the stand for long periods. Most other species will not remain in the stand under the suppressive conditions that beech will endure, and so such poor form is not manifested in these other species.

Growth And Yield

Because beech is seldom found in pure stands, and because the attention of forest managers has generally been directed to other more valuable species, there is a singular lack of information concerning the growth and yield of beech. Data on European beech are available, but they are not strictly applicable to the situation in the Northeast.

American beech has generally been dismissed with the statement that its growth is the slowest and its merchantable yield, at any given age, the smallest of any of its associates. The true picture is not so black. Much of the impression of very slow growth has been received from beech that was suppressed for long periods prior to release. Also, although growth per tree and yield per tree may be slower and lower than other species, this is offset to a considerable extent by stocking density, which changes the picture when one considers growth and yield per acre. Though in the Northeast our present utilization pattern puts the emphasis on the individual stem (whereas in some areas of Europe the emphasis is on volume per unit of area), new developments in utilization point to the increasing importance of yield of wood fiber per acre.

Growth per tree in unmanaged stands is generally slower for beech than for most of its associates. Frothingham (18) gives the growth in diameter, height, and volume for beech in virgin stands in the Lake States (table 3). In the Anthracite Region of Pennsylvania, Ferree (17) found that in sawtimber stands on site 1, beech volume increment for single trees reached a maximum of 8.0 cubic feet per last decade at 16 inches in diameter. On site 2, it reached a maximum of 6.1 cubic feet per last decade at from 14 to 16 inches in diameter. (These compare closely with the figures given in table 3). Most of the other species in Ferree's study were able to show much better growth at some time during their life. He found that only black birch, yellow

birch, and trembling aspen grew slower than beech at some stage during their lives.

A recent survey in the southern Adirondacks of New York found the average 10-year diameter growth of 135 sampled trees to be 0.97 inches (approximately 21 rings per inch of radius).[6]

Table 3.--Average growth per tree of beech in virgin northern hardwood-hemlock stands in the Lake States

Age (years)	Diameter	Height	Volume	Age (years)	Diameter	Height	Volume
	Inches	Feet	Cu.ft.		Inches	Feet	Cu.ft.
20	0.7	13	--	140	10.7	72	22.0
30	1.5	21	--	150	11.5	75	27.0
40	2.3	28	--	160	12.4	78	32.0
50	3.0	33	--	170	13.2	80	38.0
60	3.8	39	1.0	180	14.1	82	44.0
70	4.6	44	2.2	190	14.9	83	50.0
80	5.4	48	3.7	200	15.7	84	56.0
90	6.3	53	5.5	210	16.5	85	63.0
100	7.1	57	7.8	220	17.3	86	71.0
110	8.1	62	10.5	230	18.1	87	79.0
120	8.9	65	13.8	240	19.0	87	87.0
130	9.8	69	17.6	250	19.9	88	95.0

Source: Frothingham (18).

Hawes and Chandler (24) give data on growth of second-growth beech in Vermont (table 4). This shows the faster growth of which beech is capable when growing on a good site and unhindered by overhead canopy.

A consideration of yields per acre places beech in a much more favorable position. Möller (29) points out that the annual volume increment per acre of a stand, at a given age and on a given site, will correspond to the volume of leaves that can be achieved per acre. He shows that a shade-tolerant species such as European beech will attain a greater volume of leaves and hence a greater production of dry matter than most other deciduous trees. Volumes per acre for beech in European yield tables are always among the highest of the hardwoods. American beech is very shade-tolerant and

[6] Data from Adirondack-Catskill forest survey, New York State Univ. Coll. Forestry, Syracuse. December 1951.

can probably outyield in fiber most of its deciduous associates except sugar maple on an acre basis. The most extensive forest type in the Northeast in which beech is a component is the sugar maple-beech-yellow birch type. Illick and Frontz (26) show that this type, even when unmanaged, is

Table 4.--Average growth per tree of beech in second-growth unmanaged stands in Vermont, following clear-cutting

Age (years)	Diameter	Height	Volume
	Inches	Feet	Cu.ft.
20	2.0	25	0.3
30	2.9	34	.8
40	3.9	41	1.6
50	5.0	46	2.8
60	6.1	50	4.3
70	7.1	55	6.5
80	7.9	58	9.9

Source: Hawes and Chandler (24).

Table 5.--Yields of sugar maple-beech-yellow birch type in unmanaged, even-aged, fully-stocked, second-growth stands in Pennsylvania

Age (years)	Volume per acre		Age (years)	Volume per acre	
	Cu.ft.	Cords		Cu.ft.	Cords
5	175	2.05	45	3,750	44.12
10	425	5.00	50	4,025	47.35
15	775	9.12	55	4,250	50.00
20	1,200	14.12	60	4,425	52.05
25	1,775	20.88	65	4,500	52.90
30	2,375	27.94	70	4,650	54.70
35	2,925	34.41	75	4,725	55.66
40	3,375	39.70	80	4,800	56.47

Source: Illick and Frontz (26).

capable of yielding good volume-per-acre returns. They found that between the ages of 25 and 55 years, second-growth, even-aged, fully stocked stands in Pennsylvania contained as many cords per acre as the stands were old in years (table 5).

PAST CUTTING PRACTICES

In the Northeast, past cutting practices have been characterized more by poor leaving than by poor cutting. Such practices have destroyed the fine wood factory that a woodland area can be, by leaving it cluttered up with trees that are more of a liability than an asset. Such practices have often resulted in an increased proportion of beech, and in the development of a situation that has been referred to by some foresters and woodland owners as the "beech problem."

Beech lumber requires special care in drying, and techniques for eliminating the common seasoning defects have been known for some time. In the past, however, improper piling and handling have been the rule rather than the exception. The cupped, twisted, and severely checked beech lumber that resulted was largely responsible for a chain of reactions in which either beech was overlooked in logging, or only the very best of the beech was taken. Even in fuelwood cuttings, beech has been severely high-graded, for the straight, well-pruned trees split much easier than the crooked, large-limbed trees.

After cuttings where beech was left, or where it was high-graded, the residual beech responded readily to the increased light by enlarging their crowns and developing heavy limbs. Frequently they became infected with disease which gained access through logging wounds on the thin-barked stem and surface roots. In the past, logging has often been followed by fire, and the beech was seriously damaged. If not present already, root suckers were encouraged by the wounding and increased light.

Past cutting has also been characterized by a lack of attention to regeneration of the forest. Efforts to control the composition and development of the future stand by thoughtful overwood harvesting were few and far between. The perpetuation of fast-growing, intolerant species usually requires wise planning and careful execution. Shade tolerant, "intensive" reproducers like beech usually have an advantage when regeneration is left up to Nature in a high-graded forest.

Small wonder that many forest owners are dismayed by the conversion that they have seen in their lifetimes, from a stand with a small proportion of beech, to one in which the pole, sapling, or seedling classes are dominated by this

aggressive species. Typical of such stands is one on the Experiment Station Forest at Paul Smiths, N. Y., for which stand data have been gathered. Although in the mixed conifer-hardwood stand only 14 percent of the sawlog-size trees (13 inches and up) are beech, 59 percent of the stems between 1 inch and 12 inches are of this species. It is also true that of the 228 sapling- and pole-size beech stems on this average acre, only 26 are classified as being of good-quality growing stock. Because of its shade tolerance, root-suckering habits, and site adaptability, beech holds rather tenaciously any ground it gains.

Past high-grading of beech has left trees of inferior form to occupy the site. Opperman (32), who has intensively studied beech in Europe, warns that the continued removal of only the best trees over a long period of time can result in forests composed mainly of poor forms or races, where good trees are seldom found. Our increasing awareness of the role of genetics, and the increasing development of markets for low-grade wood, tend to prevent any future marked deterioration of this nature; yet it is wise to keep this warning in mind.

A POLICY OF MANAGEMENT FOR STANDS CONTAINING BEECH

The foregoing discussion has been presented in an attempt to provide the forest manager with the foundation knowledge on which to base a management policy for forest stands containing beech. A consideration of the silvicultural characteristics of this species, together with the financial aspects of producing beech or other species, will determine the policy. The policy will have to be modified to suit local economic situations and the type and condition of the forest that is being considered. Both the desirable and undesirable characteristics of beech should be considered thoroughly in formulating a plan of management. A brief review of these may provide some guidance.

Beech is excellent fuelwood and charcoaling stock, and one of the best hardwood pulpwoods. For pulpwood purposes, it responds to chemi-peeling with sodium arsenite in a spectacular way--better than any of its associates (10). Easier peeling is cheaper peeling, and this results in additional profit to the grower who is supplying peeled wood.

Beech is favored in the manufacture of baskets, and in a few other specialty uses such as clothespins.

Because of past cutting practices, we have fallen heir to a great deal of poor beech, much of which is a liability unless new bulk markets develop rapidly. A great deal of our heritage of poor-quality beech is due to mismanagement or lack of management. For instance, although crook, sweep, and other defects are common in unmanaged beech, much of this can be eliminated through intensive management.

On our better forest sites it is possible with proper silviculture to produce excellent beech. Individual trees that are favored can be grown as fast as 10 rings per inch of radius. In the production per acre per year of total wood fiber, beech ranks among the highest of deciduous trees. It can be managed successfully under any of the classical systems of silviculture, including the selection system, which is well adapted to the needs of the small farm woodlot.

In areas that are managed for recreational use, beech has an aesthetic value equalled by few other species. The use made of beech seed by many forms of wildlife adds to its value as a component of our Northeastern forests.

Offsetting these favorable aspects of beech perpetuation and production, there are several serious unfavorable aspects. Not all of the existing poor-quality beech can be attributed to a lack of good silviculture. On unfavorable sites, where beech is often found, even the most intensive kind of management would not have produced high-quality beech. In addition, root suckers, which constitute a high percentage of beech reproduction, are not rewarding to work with. Though beech can be grown at reasonable rates of growth for individual trees, many of its associates such as white ash, basswood, black cherry, white spruce, and white pine are capable of much better growth. While it is true that on the best forest sites it is possible to produce good beech, these same sites can carry species which bring the landowner greater returns not only in shorter rotation, but also in dollars received for the same sized product.

Beech is not particularly a good "risk" tree. The thin bark and surface roots leave it susceptible to injury from logging, fire, and site exposure, with the subsequent danger of such wood rots as Fomes igniarius and Polyporous glomeratus. In certain areas of the Northeast, beech is a poor risk because of the beech bark disease. Unless ade-

quate controls are found, or natural ones develop, the threatened area will embrase a large section of the Northeast. Beech is also a questionable crop in the northern and upper altitudinal limits of its range, where winter temperatures as low as -30° F. are apt to occur during the rotation. It should be remembered that it is not average conditions that determine the suitability of a species for a particular site, but the extremes, even if they occur only once or twice during the crop-growing period.

At present beech is not as financially attractive as some other species, since except for a few limited outlets such as basket manufacturing, it is less in demand and brings lower prices than all but one or two of its commercial associates. Though economic climates will undoubtedly change in the future, it is rather doubtful that the relative position of beech on the price totem-pole will change. It seems destined to be one of the low men. What can be done with beech in either production or utilization can generally be done better with sugar maple or some other associated species.

When all the evidence is weighed, a general policy applicable to many forest holdings in the Northeast develops: "Favor more rewarding species over beech wherever possible; seek to reduce its proportion in a regenerated stand; where there are pure groups or stands dominated by beech, work with and for the best individuals." It is imperative that this be implemented speedily on sites unfavorable for beech, but upon which beech has become established. It is imperative too, where the threat of beech bark disease exists. This policy is desirable on the sites favorable to beech, because there we can gradually convert to better species.

In a management program of favoring other species over beech, the forest manager should be firm and resolute, but should not blindly discriminate against the species. The silvicultural objective always should be to cut to favor the desirable individual stem, not to remove the undesirable. Vigor, stem quality, presence of defects, and species all play a part in indicating which is the best individual in a group. A good-quality beech is to be preferred over a crooked maple or a low-forking oak. There is little likelihood that any concerted program of replacing beech by other species would proceed to the virtual elimination of this species from our commercial forests. Nor is this desirable perhaps, for any species whose fruit is such an important part of the diet of many forms of wildlife has an important

role to play in the forest community. Both forest and wildlife managers might agree that beech should be reduced in proportion in the interior of the commercial woodland, but should be allowed a place.

The management that will carry out this general policy must be intensive and even drastic. Where poor-quality beech is already a large stand component, vigorous measures are needed. The even-aged forest form, maintained by a silvicultural program that keeps a dense canopy throughout the life of the stand, and then rapidly removes the mature overwood, permits the greatest discrimination against beech. The uniform-shelterwood regeneration system or patch clear-cutting are applicable to most of our Northeastern forests in which beech is a component. The presence of advanced reproduction must be assured prior to final crop removal.

Unmerchantable trees left after the harvesting should be girdled or poisoned. Poor leaving rather than poor cutting has been our primary mistake in the past. Poisoning techniques that will kill not only the parent tree but also the numerous root suckers are being investigated at the Northeastern Forest Experiment Station at Paul Smiths, N.Y., and elsewhere. Root suckers can be killed by basal stem sprays of oil-borne 2,4,5-T, or by injections of dendrocides with the Cornell Tree Killing Tool, when their presence is detrimental to the newly-regenerated forest.

SUMMARY

The commercial forest land and small woodlots of the Northeast have been bent and broken by the hammer of high-grading on the anvil of indifference. Production potential has been impaired by leaving the area cluttered up with forest junk. Much of this junk is poor-quality beech, and because of indifference about regeneration, beech has increased in proportion in the young stands. What has been termed the beech problem is in reality a segment of the larger problem of poor management or lack of management. With their production machines crippled, such forests are not in the position to produce goods that yield the owner much profit.

Present owners can make a start on a rehabilitation program by doing everything that is economically practical to put these woodlands into shape so they can produce the best species and best individuals. In this program, beech

must be reduced in favor of more valuable species. Increased utilization of beech would provide the key to make this possible.

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AGRICULTURE-FOREST SERVICE-UPPER DARBY

(CONTINUED FROM INSIDE OF FRONT COVER)

* Chemistry and chemical utilization of beech.
* Silvicultural characteristics of beech.
  Availability and supply of beech.
  Present markets and uses for beech.
* Logging beech and specifications for products.
* Seasoning beech lumber.
* Storage of beech logs and bolts.
* Machining of beech.
  Milling of beech.
* Gluing techniques for beech.
* Steam-bending of beech.
  Preservative treatment of beech.
* Beech for flooring.
  Beech for furniture.
  Beech for turned products and novelties.
* Beech for veneer and plywood.
* Beech for fuel and charcoal.
  Beech for crossties.
* Beech for containers.
  Pulping and defiberization of beech.
  Rough construction on the farm with beech.

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The information gathered in this widespread cooperative project should be of great use to the wood-using industries of the regions where the wood of American beech is available.

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